

ENVIRONMENTAL PROTECTION

UDC 666.3:628.543.504.2

PURIFICATION OF HIGHLY CONCENTRATED INDUSTRIAL SEWAGE FROM THE PORCELAIN AND FAIENCE INDUSTRY BY THE ELECTRIC FLOTATION METHOD

V. I. Il'in,¹ V. A. Kolesnikov,¹ and Yu. I. Parshina¹Translated from *Steklo i Keramika*, No. 7, pp. 23–25, July, 2002.

The mechanical methods of purification of industrial sewage generated in the porcelain and faience industry are considered. The expedience of using the electric flotation method with insoluble electrodes at the stage of separation of the solid and liquid phases using more effective flotation reactants is demonstrated. This makes it possible to shorten by several times the sewage treatment duration and to raise the degree of purification to 95–99%.

Porcelain and faience factories discharge highly concentrated industrial sewage with specific contaminants. Sewage is generated in washing of raw materials, preparation of porcelain mixtures, washing of floors and machinery, and in cooling of the compressors.

The sewage contains industrial waste components: clay, kaolin, feldspar, pegmatite, magnetite, paint-and-varnish materials, iron, hardness salts, ammonium nitrogen, etc. The averaged physicochemical parameters of the sewage are as follows: pH 7, clarity 1.5 cm, alkalinity 6 mg · equiv./liter, hardness 7 mg · equiv./liter, BOD₅ – 50–100 mg/liter, suspended compounds 1700–28,900 mg/liter. The sewage liquid has a milky color [1].

Mechanical purification methods, i.e., sedimentation (gravity and centrifugal) and filtration are widely used to purify sewage generated at porcelain and faience factories. Sedimentation requires considerable time, which is not always justified. The technological scheme for clarification of sewage using hydrocyclones and subsequent treatment on mechanical filters yields a purification effect of 20%, which is insufficient. This low clarification effect is due to the fact that the majority of suspended materials are present in the liquid in the form of a stable suspension of fine particles not detained by standard filtering materials. These particles have a negative charge. The presence of the like charge impedes the coagulation and sedimentation of particles; therefore, the particles maintain a uniform distribution over the disperse phase volume for a long time.

Thus, the equipment for purification of industrial sewage from contaminant impurities based on the traditional mechanical treatment methods is often not effective enough or cannot be applied due to a shortage of available space, or for other reasons. Therefore, the development of highly efficient equipment and techniques allowing for purification of sewage to the required parameters is a topical problem in water purification technology. The most topical areas include the development of compact automated equipment capable of preserving its operating capacity for a long time, refinement of the purification control, and using more efficient reactants.

The water purification technology usually depends on the physicochemical properties of water impurities ensuing from their phase-dispersion state. The individual chemical nature of the material has a subordinate significance. Hence it follows that the processes along the phase boundaries and the processes caused by molecular interaction are the most important. Taking into account these specifics, it is possible to solve the problem of purifying water from various chemical compounds [2].

The technological scheme, the purification facilities, and their operating conditions are selected taking into account the forces acting in an aqueous medium and the processes occurring in it (different in their physicochemical nature and character).

The D. I. Mendeleev Russian Chemical Engineering University is developing electrochemical technologies and equipment for purification of industrial sewage. The most promising electrochemical method is electric flotation. This method is sufficiently universal, highly efficient, economical, environmentally safe, and has been successfully used in

¹ D. I. Mendeleev Russian Chemical Engineering University, Moscow, Russia.

the clarification and decolorization of glasses. This method provides a high efficiency in removal of impurities existing in the forms of suspensions and emulsions and for mineralization of soluble organic compounds.

The advisability of using electric flotation for purification of sewage is related to the formation of highly disperse gas (hydrogen and oxygen) bubbles in electrolysis of the solution, which are uniformly distributed in the volume of the treated liquid. This modifies the chemical composition of the liquid and the properties and state of soluble and insoluble impurities. As the sewage liquid flows between the electrodes, electrolysis, polarization of particles, electrophoresis, and redox reactions take place; the electrolysis products react with each other and with the components. The gas bubbles, which have a high hydrodynamic lift, rising and colliding with suspended impurity particles, stick to them and float with them to the water surface, forming a stable froth layer. The small size of the electrolytic bubbles ($5 - 30 \mu\text{m}$) compared to the size of the extracted impurity particles, the possibility of gradual control of the process rate by modifying the degree of saturation of the liquid with gas bubbles, and the presence of an electrolytic surface charge in the bubbles — all this shows the advantages of the electric flotation equipment over flotation systems, hydrocyclones, and settling tanks.

Figure 1 shows the schematic design of an electric flotation system used to separate the liquid and the solid phases of sewage. The system consists of a case, a slime collector, and an electrode pile. The body is made of polypropylene and is rectangular. It is divided into two sections by a partition, each section divided by another partition into two chambers. Electrode piles are placed vertically in each chamber.

The body is equipped with inlet and outlet pipes with flanges connected with pipelines and slime collectors consisting of a scrubbing device and a geared motor.

The electrode pile consists of a set of rectangular plates 1 mm thick. The cathodes are made of stainless steel and the anodes are made of ORTA material (titanium base and an active surface coating made of a mixture of isomorphous titanium and ruthenium oxides). The distance between the electrodes is 3 mm. To prevent the formation of a sediment, crest-shaped electrodes are used which are arranged within the same plane so that protrusions of some of them enter without contact into the cavities of others.

The power supply of the electric flotator is implemented via current leads by means of a rectifier.

The equipment operates as follows. The liquid to be purified is fed into the electric flotator via inlet pipes into the first two chambers. Next, the liquid spills over the partitions into the second two chambers and via an opening in the bottom part passes into a water header. After the system is filled with the liquid, the rectifiers are turned on and voltage is supplied to the electrode leads. As a result of electrolysis, oxygen and hydrogen gas bubbles are formed on the surface of the electrodes, which then rise and react with the impurity particles

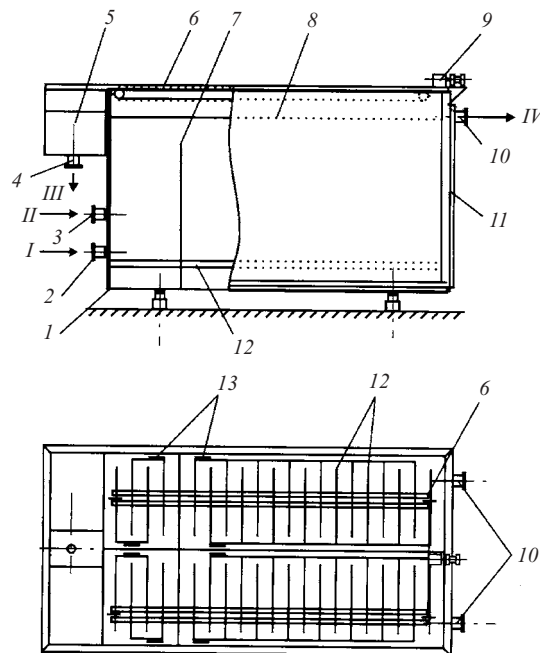


Fig. 1. Electric flotation system: 1) body; 2) water supply pipe; 3) pipe for feeding reactants; 4) slime-discharge outlet pipe; 5) slime-collecting chamber; 6) froth-collecting unit; 7 and 8) partitions; 9) geared motor; 10) water outlet pipe; 11) water header; 12) electrodes; 13) current leads; I) initial liquid; II) reactant solution; III) slime; IV) purified water.

existing in the insoluble state, due to which they stick to each other. The density of the resulting aggregates is lower than the density of water; consequently, they float on the surface of the liquid. In this way the impurities are extracted from the liquid and collected from its surface in the form of slime. The purified liquid flows out of the system via the outlet pipes. The scrubbing device shifts the slime from the surface in a direction opposite to the liquid flow and into a collecting pocket with a conic bottom located at the end of the flotator on the side of the sewage inlet. The slime is removed from the system via a branch pipe.

Its is possible to intensify the purification of sewage using additional reactants (coagulants and flocculants). In this case the reactants in the form of solutions are fed through branch connections.

The performed studies established that the most efficient reactant is aluminosilicon flocculant-coagulant AKFK (25 g/liter SiO_2 , $17 \text{ g/liter Al}_2\text{O}_3$, $0.9 \text{ g/liter Fe}_2\text{O}_3$) produced by treating nepheline concentrate with a 10% solution of sulfuric acid. The coagulating properties of AKFK are determined by the presence of aluminum and iron sulfates, whereas the dissolved silicic acid provides for the flocculant properties of the solution and of aluminum and the coagulant acting regardless of the salts. The AKFK agent is a more effective coagulant of suspended materials than iron and aluminum sulfates. For instance, introduction of 15 mg/liter AKFK into water containing 300 mg/liter suspended parti-

TABLE 1

Parameter	Purification method	
	sedimentation	electric flotation
Purification process duration, h	2.0 – 7.0	0.2 – 0.4
Specific consumption of coagulant, g/liter	0.20 – 0.40	0.02 – 0.04
Purification efficiency, %	70 – 80	95 – 99
Moisture of sediment, %	98.5 – 99.8	92.0 – 95.0
Volume of sediment, %	17.0 – 20.0	0.1 – 0.2

cles removes 92–95% of impurities, whereas the same quantity of aluminum sulfate removes only 15% of impurities. These properties of AKFK and its low cost due to inexpensive initial materials and a simple production technology determine its universal use in water purification.

The output of the system is up to 10 m³/h (the efficiency of one sections is up to 5 m³/h). The optimum height of the work zone is 0.8 m. The overall dimensions are 2100 × 1115 × 1500 mm. The specific power consumption is 0.2 – 0.4 kW · h/m³.

Table 1 shows the comparative characteristics of sewage purification by the electric flotation and sedimentation methods.

Thus, electric flotation can be successfully used to purify sewage at the stage of separation of the solid and liquid phases. Electric flotation is especially effective when used instead of sedimentation tanks, providing for a 10 – 20 times decrease in the treatment duration and a 3 – 5 times decrease in the space needed for the equipment.

The electric flotation treatment of sewage in addition to clarifying the liquid results in a disinfection of dissolved

organic impurities due to the electrochemical destruction processes.

The bacteriological analysis data indicate the disinfectant effect of the electrochemical method. The electrolysis of water containing chloride ions produces bactericide agents: hypochlorite and hypochlorous acid, which easily react with ammonium and ammonium salts present in the liquid. In this way chloramines are formed, which also have a disinfectant effect. This makes it possible to reduce the dose of biocide when using the purified liquid as make-up water in the circulating water system.

The process of electroflotation treatment of sewage within the alkaline pH range additionally decreases the hardness of water due to the formation of difficultly soluble compounds of calcium, magnesium, and other heavy metals, as well as decomposition of ammonium ions and formation of gaseous ammonia.

The developed technology and equipment make it possible to vary the degree of purification depending on the initial composition and the requirements imposed on the quality of the purified water without modifying the technological scheme and procedure of the process.

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